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मानक

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IS 13122-1 (1993): Transmitters for Use in Industrial-Process Control Systems, Part 1: Methods for Evaluating the Performance [ETD 18: Industrial Process Measurement and Control]



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“ज्ञान एक ऐसा खजाना है जो कभी चुराया नहीं जा सकता है”

Bhartrihari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”

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IS 13122 (Part 1) : 1993

भारतीय मानक

(Reaffirmed 2001)

औद्योगिक प्रक्रम नियंत्रण तंत्रों में उपयोग के लिए
ट्रांसमीटर — विशिष्ट

भाग 1 कार्यकारिता-मूल्यांकन की पद्धति

Indian Standard

TRANSMITTERS FOR USE IN INDUSTRIAL-
PROCESS CONTROL SYSTEMS — SPECIFICATION

PART 1 METHODS FOR EVALUATING THE PERFORMANCE

UDC 621.396.61 : 65.011.56 : 621-523

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

June 1993

Price Group 7

FOREWORD

This Indian Standard (Part 1) was adopted by the Bureau of Indian Standards, after the draft finalized by the Industrial Process Measurement and Control Sectional Committee had been approved by the Electrotechnical Division Council.

The methods of evaluation specified in this standard are intended for use by manufacturers to determine the performance of their products and by users or independent testing establishments to verify manufacturers' performance specifications.

This standard (Part 1) is intended to specify uniform methods of test for the evaluation of the performance of transmitters with pneumatic or electric output signals.

Part 2 of this standard provides guidance for installation, inspection and routine testing of these transmitters.

The test conditions in this standard, for example, the range of ambient temperatures and power supply, represent those which commonly arise in use. Consequently, the values specified herein shall be used where no other values are specified by the manufacturer.

The tests specified in this standard are not necessarily sufficient for instruments specifically designed for unusually arduous duties; conversely, a restricted series of tests may be suitable for instruments designed to perform within a more limited range of conditions.

It will be appreciated that the closest communication should be maintained between the manufacturer and the evaluating body while deciding the test programmes. Note shall be taken of the manufacturer's specifications for the instrument and the manufacturer should be invited to comment on both the test programmes and the results.

When a full evaluation in accordance with this standard is not required those tests which are required shall be performed and the results reported in accordance with those parts of the standard which are relevant (see Part 2) of this standard.

While preparing this standard, assistance was derived from IEC Publication 770 : 1984 ' Methods of evaluating the performance of transmitters for use in industrial-process control systems ', issued by the International Electrotechnical Commission (IEC).

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (revised)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

TRANSMITTERS FOR USE IN INDUSTRIAL- PROCESS CONTROL SYSTEMS — SPECIFICATION

PART 1 METHODS FOR EVALUATING THE PERFORMANCE

1 SCOPE

1.1 This standard is applicable to transmitters which have either a standard electric current output signal as per IS 7728 : 1984 or a standard pneumatic output signal in accordance with IS 7722 : 1975, or a standard voltage output signal as per IS 8493 : 1977.

1.2 The tests detailed herein may be applied to transmitters which have other output signals, provided that due allowance is made for such difference.

1.3 Transmitters for the measurement of electrochemical properties, such as pH transmitters, are not covered by this standard.

2 REFERENCES

The Indian Standards listed in Annex A are necessary adjuncts to this standard.

3 TERMINOLOGY

3.0 For the purpose of this standard, the following definitions shall apply.

3.1 Conformity of a curve, the closeness to which it approximates a specified curve (for example, linear, logarithmic, parabolic, cubic, square root, etc).

3.1.1 Conformity, Independent

The maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve, so positioned as to minimize the maximum deviation.

3.1.2 Conformity, Terminal-Based

The maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve coinciding with the actual characteristic at upper and lower range-values.

3.1.3 Conformity, Zero-Based

The maximum deviation of the actual characteristic (average of upscale and downscale readings) from a specified curve so positioned as to coincide with the actual characteristic at the lower range-value and to minimize the maximum deviation.

3.2 Dead Band

The largest change in input that can be effected without causing a detectable change in output.

3.3 Hysteresis

That property of an element evidenced by the dependence of the values of the output, for a given excursion of the input, upon the history of prior excursion the direction of the current traverse.

3.3.1 Hysteresis Error

That portion of hysteresis due to energy absorption in the elements of a measuring instrument. Unless otherwise specified it should be determined by subtracting the effect of the dead band from the maximum measured separation between upscale-going and downscale-going indications of the measured variable during a full range traverse.

3.4 Range

The region between the limits within which a quantity is measured, received or transmitted; limits are given by stating the lower and upper range-values.

Example : 0 Pa, 20 Pa, or 4 mA, 20 mA.

NOTE – Transmitters may be supplied with manual or automatic means of adjusting the range. As used in this standard the term "range" and the definitions below apply to the characteristics of the transmitter for a specified setting of the adjustment means.

3.4.1 Elevated Zero Range

A range in which the zero value of the measured variable is greater than the lower range-value.

Example : – 10°C to +30°C.

3.4.2 Lower Range-Value

The lowest value of the measured variable that a device is adjusted to measure.

3.4.3 Upper Range-Value

The highest value of the measured variable that a device is adjusted to measure.

3.4.4 Span

The algebraic difference between the upper and lower range-values, for example : 16 mA when the range is 4 mA to 20 mA or 20 Pa when the range is 0 Pa to 20 Pa.

3.4.5 Suppressed Zero Range

A range in which the zero value of the measured variable is less than the lower-range-value, for example 200°C to 500°C.

3.5 Repeatability

The closeness of agreement among a number of consecutive measurements of the output for the same value of the input under the same operating conditions, approaching from the same direction, for full range traverses.

3.6 Transmitter

A device which responds to a measured variable to produce a standard output signal for transmission which has a prescribed continuous relationship to the value of the measured variable.

3.7 Zero Adjustment

A means provided in an instrument to cause a parallel shift in the input-output curve.

4 GENERAL TESTING PROCEDURES

4.1 Selection of Ranges for Test

Unless otherwise specified by the manufacturer where the span is adjustable other than to take up manufacturing tolerances, the tests shall be carried out with the span adjustment set approximately at the manufacturer's stated minimum and maximum and at an intermediate value.

4.1.1 Unless otherwise specified by the manufacturer, where the zero adjustment is adjustable other than to take up manufacturing tolerance, such as devices equipped with means for suppression or elevation of zero, the tests shall be carried out with the elevation/suppression adjustment set for its minimal effect, then at its extremes.

If the extent of adjustment is more than twice the maximum span, tests shall also be carried out with the adjustment set approximately at the arithmetic mean of the two extreme values of elevation and/or suppression.

4.1.2 Testing of a transmitter with provision for substantial adjustment of both span and zero in accordance with 3.1.1 and 3.1.2 may require an impractically large number of tests. Preliminary tests should be conducted to determine the effect of changing span and zero adjustments on the characteristic being measured so that redundant tests can be eliminated from the test programme in cases where the characteristic can be inferred reliably from fewer tests. For example, hysteresis and dead band may not be significantly affected by selection of the lower and upper range value if the span is held constant, and often may be calculated for different spans from measurements at a single span setting. In any case the report should clearly indicate relevant values of the measured parameters for each setting of the adjustments so that the values of measured error, hysteresis, dead band, etc. are all referenced to the same adjustment of the transmitter.

4.2 Zero and span should be adjusted to make the actual characteristic conform closely to ideal values at the upper and lower range limits before the tests specified in each clause of this standard. When this is done the fact shall be stated in the evaluation report.

4.3 Unless otherwise stated, the test results shall be expressed as percentages of output span.

4.4 When performance characteristics are specified, they shall be tabulated beside the actual test results.

4.5 The limit of error of the measuring systems used for the test shall be stated in the test report and should be smaller than or equal to one-fourth of the stated limit of error of the instrument tested (see 5.5.1).

4.6 An adequate time, as specified by the manufacturer, shall be allowed after switching on the power supply in order to allow temperature within the transmitter to stabilize. In the absence of manufacturer specification, a period of at least 15 min should be allowed.

4.7 Errors shall be expressed as departure from the input/output relationship specified by the manufacturer.

For example : A 'temperature transmitter' may have an output intended to be linear with respect to input emf or incorporate a network intended to linearize the output with respect to temperature. To determine the error in the first example, the input/output relationship would be emf to output; in the second example, it would be temperature to output. Although the same test procedure may be applied, the errors shall be assessed differently.

5 ENVIRONMENTAL TEST CONDITIONS

5.1 Standard Reference Atmosphere

Temperature	27°C
Relative humidity	65 percent
Atmospheric pressure	101.3 kPa

This standard reference atmosphere is that atmosphere to which values measured under any other atmospheric conditions are corrected by calculation.

It is recognized that in many cases a correction factor for humidity is not possible. In such cases the standard reference atmosphere takes account of temperature and pressure only.

This atmosphere is equivalent to the normal reference operating conditions usually identified by the manufacturer.

5.2 Recommended Range of Ambient Conditions for Test Measurements

Temperature	15°C to 35°C
Relative humidity	45 percent to 75 percent
Atmospheric pressure	86 kPa to 106 kPa
Electromagnetic field	Value to be stated, if relevant

The maximum rate of temperature change permissible during any test shall be 1°C in 10 min. These conditions may be equivalent to normal operating conditions.

5.3 Reference Conditions During Tests

5.3.1 Electrical Supply

- Rated voltage
± 1 percent
- Rated frequency
± 1 percent
- Harmonic distortion (ac supply)
Less than 5 percent
- Ripple (dc supply)
Less than 0.1 percent.

NOTE - Tolerances are not applicable to transmitters with self-contained power supplies.

5.3.2 Pneumatic Supply

- Rated pressure
± 1 percent

- b) Supply air temperature
Ambient temperature $\pm 2^{\circ}\text{C}$
- c) Supply air humidity
Dew-point at least 10°C below transmitter body temperature
- d) Oil and dust free

NOTE – An oil content not greater than one part per million and absence of dust particles greater than $3\text{ }\mu\text{m}$ is considered to be an 'oil and dust free' supply.

5.4 Load Impedance

The value given by the manufacturer shall be used for electric transmitters. If the manufacturer gives a range of values, the load impedance taken shall be equal to:

- the minimum value specified by the manufacturer for transmitter with direct voltage output signal; and
- the maximum value specified by the manufacturer for a transmitter with direct current output signal.

Unless otherwise stated by the manufacturer, for pneumatic transmitters an 8 m length of 4 mm internal diameter rigid pipe followed by a 20 cm^3 capacity shall be used.

NOTE – Care should be taken to ensure that pneumatic connections are leak-tight.

5.5 Other Conditions

Spurious induced voltage or pressure fluctuation shall have negligible effect on the measurement.

Transmitter position during the test shall be any normal operating position specified by the manufacturer. Only one of the permitted positions shall be used throughout the tests.

External mechanical constraints shall be negligible.

When normal operation requires a flow of process fluid through the measuring element, the flow rate shall be adjusted to the mean of the maximum and minimum values specified by the manufacturer. The temperature of the fluid shall be maintained within $\pm 2^{\circ}\text{C}$ of a value within the range specified by the manufacturer. The composition of the fluid shall be such that it will not have an adverse effect on the instrument under test.

5.5.1 Accuracy of Method of Measurement

The result of a measurement should be recorded in a measurement report. The method of measurement should be two class indices better than the accuracy class given in the instrument manual.

The maximum resultant error of the instruments/standards which measure the inputs (measurands) and the output should be below the value indicated in the table.

*Class Index of the
Transmitted to be
Measured*

*Maximum
Possible Error
of the Instruments/
Standards*

0.16	± 0.04
0.25	± 0.06
0.4	± 0.1
0.6	± 0.15
1.0	± 0.25
1.6	± 0.1
2.3	± 0.6

6 SAMPLE CALCULATIONS

6.0 Sample measurement tabulation and the deviation curves are given in Table 1 and Fig. 1.

6.1 From col 9 in Table 1, we observe that the greatest positive deviation from an average occurs at 20 percent and 30 percent input on the downscale measurements and is 0.25 percent.

From col 8 in Table 1 we find that the greatest negative deviation from an average occurs at 70 percent input on the upscale measurements and is 0.3 percent.

6.2 Conformity

6.2.1 It is usually measured in terms of non-conformity and expressed as conformity; for example, the maximum deviation between an average curve and a specified curve. The average curve is determined after making two or more full-range traverses in each direction. The value of conformity is referred to the output span unless otherwise stated.

6.2.2 As a performance specification, conformity may be expressed as independent conformity, terminal-based conformity, or zero-based conformity.

6.2.3 Linearity is a specific, but often used, case of conformity where the specified curve is a straight line.

6.2.4 The terminal-based straight line has a slope of 0.001 5 and a value of 0.05 at 0 percent input. The largest average negative deviation occurs at 70 percent input and is -0.225 . The intercept of the terminal based straight line at 70 percent input is $+0.55$. Therefore, the negative value of conformity is -0.280 .

The largest average positive deviation occurs at 20 percent input and is $+0.175$. The intercept of the terminal based straight line at 20 percent input is -0.020 . Therefore, the positive value of conformity is $+0.195$.

6.3 Hysteresis (Hysteresis Error Plus Effect of Dead Band)

6.3.1 The largest difference between the average values for upscale and downscale measurements occurs at 40 percent input and is 0.20 percent.

6.4 Repeatability

It is usually measured in terms of non-repeatability, but expressed as repeatability.

6.4.1 The formula for calculating repeatability is :

$$[(x_i - \bar{x})^2 / N]^{1/2}$$

Table 1 Sample Measurement Tabulation
(Clauses 6.0 and 6.1)

Error (Percentage of Output Span)									
Input (percent)	Up Actual	Down Actual	Up Actual	Down Actual	Up Actual	Down Actual	Up Average	Down Average	Average Error
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
0	-	-0.04	-	-0.05	-	-0.06		-0.05	-0.05
10	+0.06	+0.14	+0.04	+0.15	0.05	+0.16	+0.05	-0.15	+0.10
20	+0.13	+0.23	+0.08	+0.26	+0.09	+0.26	+0.10	+0.25	+0.175
30	+0.11	+0.24	+0.09	+0.25	+0.10	+0.26	+0.10	+0.25	+0.175
40	-0.04	+0.13	-0.07	+0.15	-0.04	+0.17	+0.15	+0.45	+0.05
50	-0.18	-0.02	-0.16	+0.01	-0.13	+0.01	-0.16	0.00	-0.08
60	-0.27	-0.12	-0.25	-0.10	-0.23	-0.08	-0.25	-0.10	-0.175
70	-0.32	-0.17	-0.30	-0.16	-0.28	-0.12	-0.30	-0.15	-0.225
80	-0.27	-0.17	-0.26	-0.15	-0.22	-0.13	-0.25	-0.15	-0.20
90	-0.16	-0.06	-0.05	-0.05	-0.14	-0.04	-0.15	-0.05	-0.10
100	+0.09	-	+0.11	-	+0.10	-	+0.10	-	+0.10

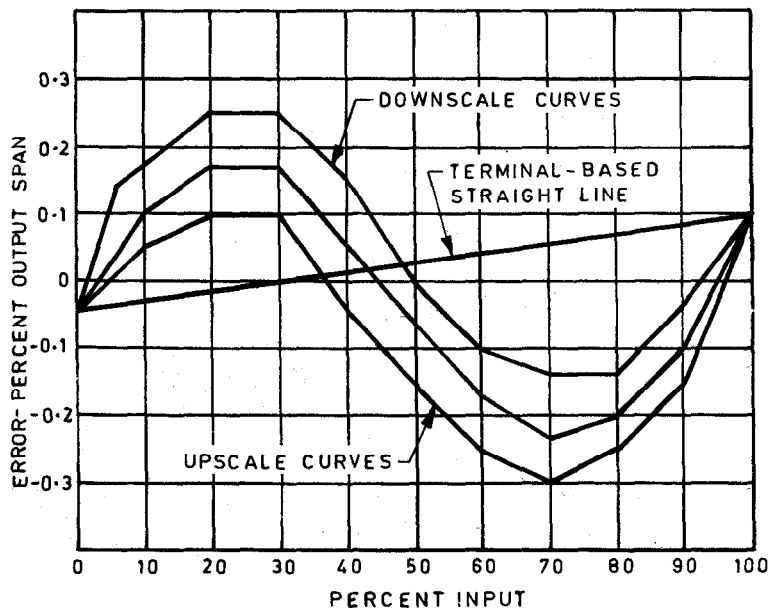


FIG. 1 DEVIATION CURVES

By inspection of Table 1 it can be determined that the greatest deviation between actual error values (x_i) and the average upscale error ($\bar{x}$) or average downscale error occurs at 20 percent input, relative to the upscale values. Therefore, the sample calculation is provided for these values.

For 20 percent upscale input, $\bar{x} = 0.10$ and $N = 3$.

x_i	$x_i - \bar{x}$	$(x_i - \bar{x})^2$
+0.13	+0.03	0.000 9
+0.08	-0.02	0.000 4
+0.09	-0.01	0.000 1
		0.001 4

$$\text{Repeatability} = (0.001\ 4/3)^{\frac{1}{2}} = (0.000\ 47)^{\frac{1}{2}} = 0.021\ 6$$

This calculation shall be performed for all input values and the largest chosen as the assigned repeatability for those test cycles.

7 STATIC BEHAVIOUR

7.1 Accuracy Related Terms

7.1.1 General

The device under test and the associated test equipment shall be allowed to stabilize under steady-state environmental conditions. All testing shall be done under these conditions. Environmental conditions which may influence test results shall be observed and recorded.

The number of test points to determine the performance characteristics of a device should be distributed over the range. They should include points at or near (within 10 percent of span) the lower and upper range-values. There should be not less than five points and preferably more. The number and location of these test points

should be consistent with the degree of exactness desired and the characteristic being evaluated.

Prior to recording observations, the device under test shall be exercised by three full-range traverses in each direction.

At each point being observed, the input shall be held steady until the output of the device under test becomes stabilized at its apparent final value.

Tapping or vibrating the instrument under test is not allowed unless the performance characteristic under study requires such action.

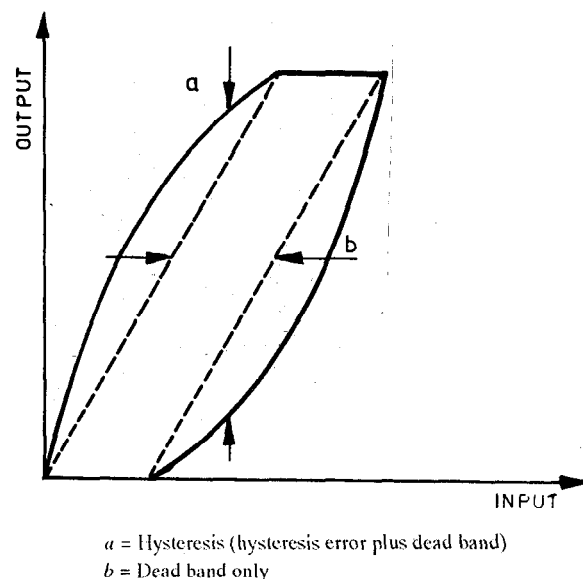


FIG. 2 HYSTERESIS

7.1.2 Measurement Cycle

Maintain test conditions and pre-condition the device under test as indicated in 7.1.1. Observe and record output values for each input value for at least three, but preferably five, full range traverses in each direction.

7.1.2.1 Error tabulation

The difference between each observed output value and its corresponding ideal output value shall be determined. This difference is the error and shall be expressed as a percent of output span. A positive error denotes that the observed output value is greater than the ideal output value.

The following shall be computed :

- a) *Average upscale error* – The arithmetic mean of the errors at each value of input for the upscale readings of each measurement cycle;
- b) *Average downscale error* – The arithmetic mean of the errors at each value of input for the downscale readings of each measurement cycle; and
- c) *Average error* – The arithmetic mean of all upscale and downscale readings at each value of input.

Record error values, average upscale error values, average downscale error values, and average error values in a table such as illustrated in Table 1.

7.1.2.2 Error curve

Plot the following error curves versus per input (see Fig. 1) shall be plotted.

- a) Average upscale error,
- b) Average downscale error, and
- c) Average error.

7.1.3 Conformity, Terminal-Based

Terminal-based conformity may be determined directly from the error curve (see Fig. 1).

A straight reference line or other reference curve shall be drawn such that it coincides with the average error curve at the upper range-value and the lower range values.

Terminal-based conformity is the maximum deviation between the average error curve and the straight line or reference curve. It is expressed as a plus or minus percent of ideal output span (see Table 1).

NOTES

- 1 The graphical methods described in this standard illustrate the nature of the computation to be made. Other methods, for example computer reduction of data, may be used.
- 2 From the measurements taken it is also possible to compute 'independent conformity' and 'zero-based conformity'. If conformity is presented according to these bases the fact should be stated clearly in the report.
- 3 If the instrument has a C-shaped curve a statement of terminal conformity will yield a larger value than if the instrument has an S-shaped curve.

If the use of the instrument permits adjustments to minimize conformity errors, the value of independent

conformity is a useful figure.

7.1.4 Hysteresis

Hysteresis is the difference between the values of the average upscale error and the average downscale error at each value of input.

Report as the value of hysteresis the largest difference as determined above.

7.1.5 Repeatability

Repeatability can be determined directly from the error values of a number of test cycles. Repeatability shall be computed as the root mean square of the deviations from the average of a number of observations.

Repeatability shall be expressed as a percentage of the output span using the worst value obtained above. (See Table 1, and 5 for illustrative examples.)

NOTES

- 1 In some cases determination of the point at which the value of repeatability is greatest will be aided by plotting all the error values for the measurement cycles on the error curve.
- 2 The value of repeatability determined in accordance with this subclause is intended for comparison of the performance of similar devices. It is not intended to be a statistically valid measure of repeatability which may be observed in service.

7.1.6 Dead Band

Dead band shall be measured at the upper and lower range-values and at a point midway between these values by proceeding as follows:

- a) Slowly vary (increase or decrease) the input until a detectable output change is observed;
- b) Observe the input value;
- c) Slowly vary the input in the opposite direction until a detectable output change is observed; and
- d) Observe the input value.

The increment through which the input signal is varied (difference between steps 2 and 4) is the dead band. It is determined from a minimum of three cycles and preferably five cycles (steps 1 to 4). The maximum value shall be reported.

Dead band shall be expressed in percent of input span. It is unnecessary in most cases to continue the test if the dead band is less than 0.1 percent.

If measurement at upper and lower range-values is impractical the measurement may be made at other values, for example 10 percent and 90 percent of range.

7.2 Effects of Influence Quantities

Unless otherwise stated, these effects shall be assessed by determining the change in the lower range-value and the span due to the following changes in conditions of use taken individually. The other conditions of use remain constant at the reference values. Rates of change of influence quantities shall be sufficiently slow to ensure that no overshoot occurs at any location in the transmitter under test.

NOTE — If necessary measurement of output should be made at several input values to permit assessment of any significant effect of influence quantities on conformity, hysteresis, etc.

7.2.1 Electrical Power Supply Aberrations

7.2.1.1 Mains power supply variations

This test shall be carried out by measurement of the changes in lower range-value and span caused by the following variations in the power supply in combination (that is, nine sets of measurement for ac supplies and three sets of measurements for dc supplies), the load resistance being as specified in 5.4.

- a) *Voltage*
 - i) nominal value,
 - ii) +10 percent or the manufacturer's limit, if less, and
 - iii) -15 percent or the manufacturer's limit, if less
- b) *Frequency*
 - i) Nominal value, and
 - ii) +2 percent -10 percent or the manufacturer's limit, if narrower.

Under low voltage/low frequency conditions, a check shall be made to establish that with the input at the upper range-value, the output does not limit below its upper range-value.

7.2.1.2 Power supply interruptions

The purpose of this test is to determine the behaviour of the transmitter when switching to a standby supply. The input shall be held constant at 50 percent of span. Short interruption (electric transmitter only).

The power supply shall be interrupted for 5 ms, 20 ms, 100 ms, 200 ms and 500 ms for dc supply or 1, 5, 10 and 25 cycles at the crossover point ac for supply.

The following values shall be recorded:

- a) The maximum transient negative and positive change in output;
- b) The time takes for the output to reach 99 percent of its steady-state value following reapplications of power; and

- c) Any permanent change in output.

If switching occurs at random phase this test should be repeated ten times, the period of time between any two tests being at least equal to ten times the duration of the test. If switching is at the crossover point only three tests are necessary.

7.2.1.3 Power supply depression

With the transmitter set at output upper range-value, the power supply voltage shall be reduced to 75 percent of nominal value for a period of 5 s. The change in output and the amplitude and duration of any transient shall be recorded.

7.2.1.4 Mains power supply transient over voltages (see Fig. 3)

Voltage spikes shall be superimposed on the mains supply. The spike energy shall be 0.1 J, and the spike amplitudes shall be 100 percent, 200 percent and 500 percent overvoltage (percentage of nominal mains rms voltage). The spikes may be generated by capacitor or by any means giving an equivalent waveform.

The power supply lines shall be protected by a suitable suppression filter, consisting at least of a check of 500 μ H, capable of carrying the line current.

The pulse of each amplitude phased to mains peak voltage shall be applied, or alternatively, at least ten pulses randomly phased with respect to the main supply. Any transients or dc output changes appearing at the output of the instrument shall be recorded.

7.2.2 Pneumatic Supply Variations

This test shall be carried out at 100 percent output by measuring the effect of a variation of ± 10 percent about the nominal reference supply pressure to the transmitter.

7.2.3 Reverse Supply Voltage Protection

For transmitters incorporating protection against power supply reversal, the maximum allowed reverse power supply voltage shall be applied.

7.2.4 Electrical Interference (Applicable to Transmitters with Electrical Input)

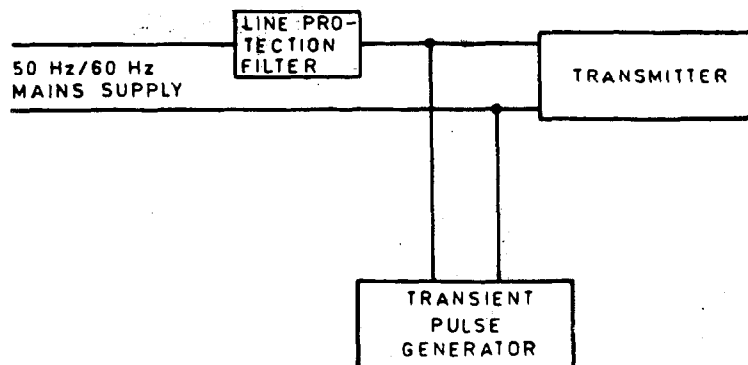


FIG. 3 SCHEMATIC DIAGRAM OF POWER SUPPLY TRANSIENT OVERVOLTAGES

7.2.4.1 Common mode interference. (see Fig. 4)

This test is only applicable to transmitters with terminals which are isolated from earth.

It shall be carried out by measurement of changes in the lower range-value and span caused by the superposition of an ac signal of 250 V rms at mains frequency between earth and each input and output terminal in turn. If the manufacturer specifies a value less than 250 V then this lower value shall be used instead. The phase of the interfering signal shall be varied over 360° with respect to the phase of the mains input to transmitter power supply.

both input or both output terminals simultaneously. If the impedance between terminals is low relative to impedance to earth both test methods yield equivalent results. The method described above has been chosen to promote consistency of method and result among testing agencies for a wide range of devices.

7.2.4.2 Series mode interference (see Fig. 5)

This test is used to determine the influence on the output of an ac signal (series mode signal) at mains frequency superimposed on the input signal.

The superimposed voltage is obtained across the secondary of a transformer shunted with a parallel resistance

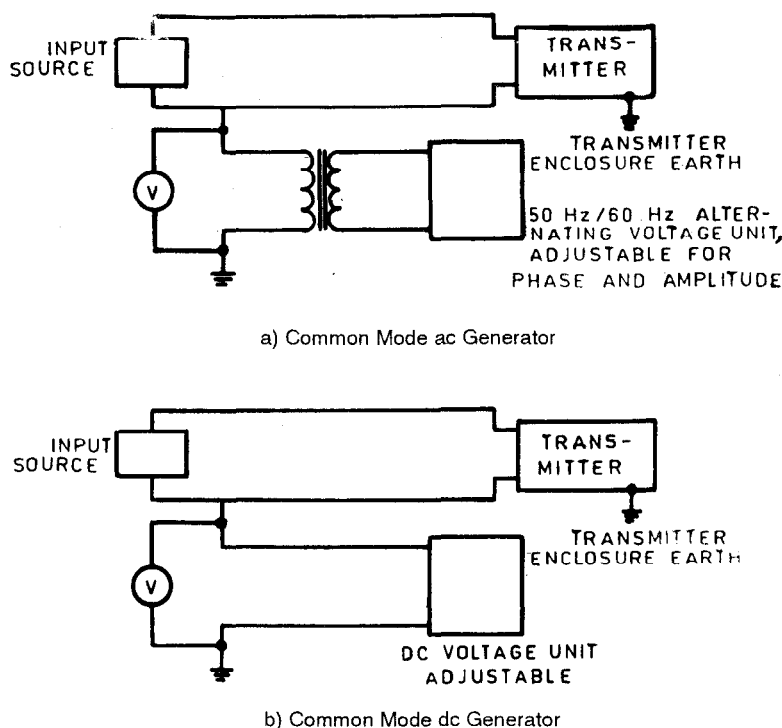


FIG. 4 COMMON MODE INTERFERENCE

The test shall then be repeated using a direct instead of an alternating voltage. A potential of 50 V dc or 1 000 times the input span, whichever is less, shall be used, both positive and negative potentials being supplied. If the manufacturer specifies a value less than 50 V, this lower value shall be used. As previously, the voltage shall only be applied to output terminals that are isolated from earth.

During the common mode interference tests, the transmitter shall be applied from an input signal source which is not affected by the common mode signal. For current-input transmitters the signal source shall be a current source with not less than 10 μ F capacitance connected across its output terminals. For voltage-input transmitters the signal source shall be a voltage source with an output impedance no greater than 100 ohms at mains frequency.

NOTE — Common mode interference tests are also commonly conducted by connecting the test signal to

of 10 ohms maximum and connected in series with the input.

The side of the parallel connection of the transformer secondary and loading resistor not directly connected to the transmitters should be earthed. For instruments with isolation between input and output, the output should be earthed when input is being measured. Measurements should be carried out for output values of 10 percent and 90 percent.

By adjusting the primary voltage the series mode voltage across the loading resistor shall be set to 1 V, peak value, with connection to the transmitter open-circuited. The transmitter is then connected into the circuit, and the change in the mean value of the output signal is measured. The phase of the transformer voltage shall be set so that the change of the output current has its maximum value. The change of the mean dc value of the output signal is noted, if small or less than 0.5 percent of the actual span. If the measured change is

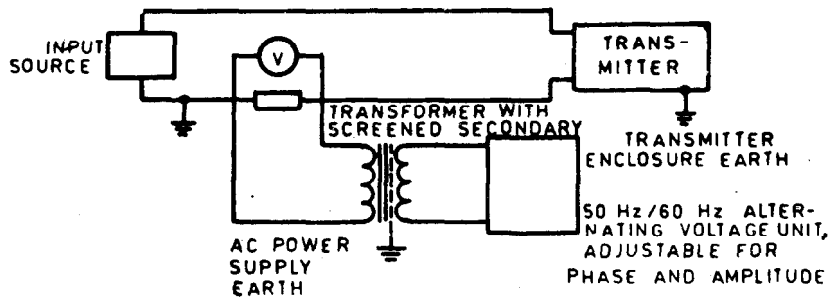


FIG. 5 SERIES MODE INTERFERENCE

greater than 0.5 of span, the series mode voltage is reduced by reducing the primary voltage until the change in the output signal equals 0.5 percent of span. The corresponding value of the series mode voltage shall be stated.

7.2.5 Earthing

This test is applicable only to transmitters with electrical inputs and outputs isolated from earth.

The test shall be carried out by measurement of the steady-state change of the lower range value and span caused by earthing each input and output terminal in turn.

Any transient changes shall be noted.

Care should be taken to eliminate any effect due to earthing of the test signal source.

7.2.6 Output Load

7.2.6.1 Evaluation of the complementary error due to electric load variation

After setting the rated supply voltage, read the output change at the values of the load for $R_{load\ min}$, $R_{load\ max}$ and $(R_{load\ min} + R_{load\ max})/2$. Measurements must be made at least three times in every point. The two wire transmitter must be examined for the full range of permissible supply voltage. The highest output change expressed in percent of the output range is the complementary error of the transmitter due to load variation.

7.2.6.2 Output load (electrical)

This test shall be applied to transmitters with electrical output signals. It shall be carried out by measurement of the changes in lower range-value and span caused by variations of load resistance from the minimum to the maximum value specified by the manufacturer. The output changes shall be expressed in percent of output span.

7.2.6.3 Output load (pneumatic)

This test shall be carried out with the input set at 10 percent, 50 percent and 90 percent of span. Varying amounts of air shall be bled from the transmitter output connection and the output pressure measured for each delivered flow rate. Varying amounts of air shall then be bled into the transmitter output connection and the output pressure measured for each exhausted flow rate.

The pressure shall then be plotted against flow in accordance with Fig. 6. From the graph will be determined :

- Maximum delivered flow rate (20 kPa output) ;
- Maximum exhausted flow rate (100 kPa output);
- Output pressure change when delivering 0.2 m³/h and 0.4 m³/h of air (at reference conditions) ; and
- Output pressure change when exhausting 0.2 m³/h and 0.4 m³/h of air (at reference conditions).

Air supply pressure shall be maintained at its nominal level throughout the test.

A discontinuity in the flow characteristic is termed "the output relay dead space" (Fig. 6) and the height of the step of this discontinuity shall be expressed as a percent of span. The corresponding air flow (delivered or exhausted) shall also be recorded.

7.2.7 Source Impedance Lead Resistance

On transmitters, the input to which is an electrical voltage, the change in output caused by varying the resistance the input circuit from the minimum value specified by the manufacturer to the maximum value shall be measured. The resistance shall be distributed equally in each line.

7.2.8 Radio Interference

Tests of the effect on the output of radio frequency interference shall be the subject of specific agreement between manufacturer and user.

7.2.9 Magnetic-Field Interference

The purpose of this test is to determine the effect of a mains frequency alternating field on the output of a transmitter. It is not applied to instruments using pneumatic signals only.

The instrument shall be exposed to magnetic field of 400 A/m (rms) which is directed along the major axis of the instrument.

The effect of the field on the mean dc level and on the ripple content of the output shall be determined for output signals of 10 percent and 90 percent span. The test shall be repeated with the magnetic field directed along two additional axis mutually perpendicular to the first.

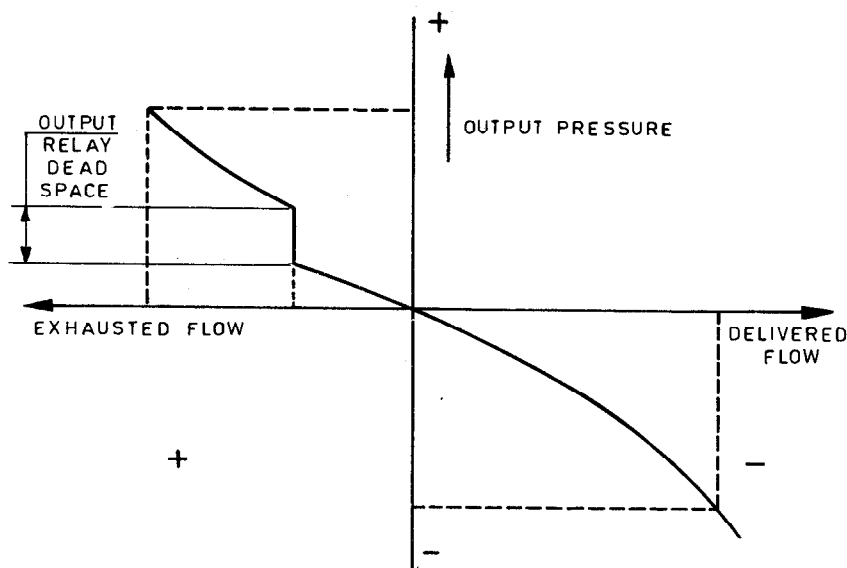


FIG. 6 FLOW CHARACTERISTICS OF A PNEUMATIC TRANSMITTER

NOTE — A magnetic field of approximately 400 A/m will be obtained at or near the centre of a circular coil of 1 m diameter, having 80 turns and carrying 5 A.

7.2.10 Ambient Temperatures

[see IS 9000 (Part 2/Sec 1 to 4) : 1977 and IS 9000 (Part 3/Sec 1 to 5) : 1977 and IS 9000 (Part 14/Sec 1 to 3) : 1988].

The changes in the value of the lower range-value and span shall be measured at the maximum and minimum operating temperature specified by the manufacturer, and, if they are included in this operating range, at each of the following ambient temperatures :

+20°C, +4°C, +55°C, +20°C, 0°C, -10°C, -25°C, +20°C.

The temperature shall be changed step by step, in the order given, and without any adjustment of the transmitter. A second temperature cycle, identical to the first, shall be performed without readjustment of the transmitter.

The tolerance for each temperature is $\pm 2^\circ\text{C}$. Sufficient time shall be allowed for stabilization of the temperature at all parts of the transmitter. For transmitters with a pneumatic output the air supply temperature shall be the same as the transmitter temperature.

7.2.11 Humidity

[see IS 9000 (Part 4) : 1979 and IS 9000 (Part 5/Sec 1 and 2) : 1981].

The transmitter shall be maintained at ambient test conditions for 24 h. A set of reference measurements shall be taken at intervals of 20 percent of the output span. The transmitter shall then be maintained for a period of at least 48 h in a chamber at atmospheric pressure at a temperature of $40 \pm 0.5^\circ\text{C}$, and a relative

humidity of 91 percent. The transmitter shall be switched on for the final 4 h of the above period and measurements shall be taken immediately following this period at intervals of 20 percent of the output span.

With the transmitter still in operation, the temperature shall be allowed to fall below 25°C in not less than 1 h. The chamber shall remain closed so that saturation shall take place during this period. The maximum change in lower range-value and span due to this condition shall be determined and recorded.

After this test, a visual inspection shall be conducted to check for signs of flashover, accumulations of condensate, deterioration of components, etc.

Immediately after a further period of 24 h at ambient conditions, the transmitter error shall be determined at intervals of approximately 20 percent span for upscale and downscale signals. Changes in error from those measured initially under ambient conditions shall be recorded.

7.2.12 Mounting Position

The change in lower range-value and span caused by $\pm 10^\circ$ inclinations from the position(s) specified by the manufacturer shall be measured and recorded. Four measurements shall be made with tilt applied in two planes at right angles to each other.

Where a $\pm 10^\circ$ inclination is excessive due to the design of the transmitter, the maximum inclination specified by the manufacturer shall be used.

7.2.13 Shock

This test shall be made according to the test procedure given in IS 9000 (Part 7/Sec 3) : 1979. Before the test reference measurements of lower range-value and span shall be recorded.

The object of this test is:

- to represent knocks and jolts likely to occur during transportation repair work or rough handling in use; and
- to verify the minimum degree of mechanical ruggedness.

The procedure of 'dropping on to a face' shall be applied as follows :

The transmitter standing in its normal position of use on a smooth, hard, rigid surface of concrete or steel, is tilted about one bottom edge so that the distance between the opposite edge and the test surface is 25 mm, 50 mm or 100 mm (value chosen by agreement between manufacturer and user), or so that the angle made by the bottom and the test surface is 30°, whichever condition is the less severe. It is then allowed to fall freely onto the test surface.

The transmitter shall be subjected to one drop about each of the four bottom edges.

After this test, the transmitter shall be examined for damage. Any change in lower range-value and span shall be recorded. It shall be verified that the transmitter can be readjusted to the initial performance.

7.2.14 Mechanical Vibration

This test shall be performed according to IS 9000 (Part 8) : 1981 or according to the following rules, except when otherwise stated by the manufacturer. The object is first to measure the changes in lower range-value and span induced by mechanical vibrations likely to be met in service, secondly to ensure that the transmitter is satisfactorily robust for these conditions.

The vibration tests are performed on the transmitter with normal supply and 50 percent input.

The transmitter shall be mounted, in accordance with the manufacturer's instructions for normal installations, on a vibration table and subjected to sinusoidal vibrations in three mutually perpendicular axis, one of which shall be the vertical direction. The rigidity of the vibration table, of the mounting plate, of any mounting

brackets used for supporting the instrument, shall be such that the impulse is transferred to the instrument with the minimum of loss.

There are three distinct stages in this test:

First stage — Initial resonance search.

The object of this stage is to investigate the transmitter response to vibrations, to determine resonance frequencies and to collect information which is necessary for final resonance search and for endurance conditioning at resonance frequencies, if necessary.

During the frequency sweeping, frequencies shall be noted which causes :

- significant changes in the output signal, and
- mechanical resonances.

All the amplitudes and frequencies at which these effects occur shall be noted in order to be compared with those found during the final resonance search specified in Table 2.

Frequency sweeping shall be continuous and logarithmic. The sweep rate shall be approximately 0.5 octave per minute. The frequency range to be used for the evaluation of industrial-process control transmitters should be taken from the table below and selected according to the type of operating conditions and kind of installation.

Second stage — Endurance conditioning.

The transmitter shall be subjected to vibration for 1.5 h each in three mutually perpendicular planes, one of which shall be the vertical direction. In each plane the test shall be run at that frequency which resulted in the largest mechanical resonance during the initial resonance search, or if no resonances were detected, at the maximum frequency specified for the type of operating conditions and installation.

Third stage — Final resonance search.

The final resonance search shall be made in the same way as the initial resonance search and with the same vibration characteristics. The resonance frequencies, and the frequencies which cause significant changes in the output signal, found in the initial resonance search

Table 2 Operating Conditions
(Clause 7.2.14)

Installation (1)	Vibration Frequency (2)	Peak Amplitude (mm) (3)	Peak Acceleration (m/s ²) (4)
i) Control room (General application)	10 to 60	0.07	—
ii) Field (Low vibration level)	60 to 150	—	9.8
iii) Field (General application)	10 to 60	0.14	—
iv) Pipeline (Low vibration level)	60 to 500	—	19.6
v) Pipeline (General application)	10 to 60	0.21	—
vi) Extreme vibration levels	60 to 2 000	—	29.4

NOTE — The crossover frequency between constant amplitude and constant acceleration is nominally 60 Hz.

and final resonance search shall be compared. Differences can be caused by non-elastic deformation which may in turn cause cracks in the mechanical construction.

Final measurements

The satisfactory mechanical condition of the transmitter shall be verified at the end of the test. Any change of calibration shall be recorded.

7.2.15 Over-Range

This test shall be carried out by measuring the changes in lower range-value and span which result from over-ranging at the minimum and maximum span.

The input shall be increased gradually from the lower range-value to the maximum over-range specified by the manufacturer.

After the over-range has been applied for 1 min, the input shall be reduced to the nominal lower range-value. After a further 5 min have elapsed, the lower range-value and the span shall be determined.

If the transmitter is to be tested for over-range effect in both direction as with differential pressure transmitters and transmitters whose input may be both below the lower range-value and above the upper range-value, it shall be tested as described above, first over-ranging above the upper range-value, it shall be tested as described above, first over-ranging above the upper range-value, and then over-ranging below the lower range-value. The values of lower range-value and span determined after over-ranging in each direction shall be recorded.

For certain types of transmitters the testing procedure shall be defined in agreement with the manufacturer.

NOTE — If over-ranging produces significant thermal effects, the duration of application should be increased until steady-state is achieved.

7.2.16 Static (Process) Pressure

This test shall be carried out, as specified by the manufacturer, on transmitters other than pressure transmitters which in normal operation are subjected to process pressure. The changes in lower range-value and span caused by changing static pressure in the measuring element shall be measured and recorded. The pressure shall be changed in four equal steps from atmospheric to the full working pressure of the instrument. For some transmitters, this test is also carried out below atmospheric pressure.

NOTE — Due attention should be given to the effect of changes in pressure in a closed system caused by changes in ambient temperature and the difficulty of measuring the change of span at high static pressure.

7.2.16.1 Static process pressure

This test shall be carried out, as specified by the manufacturer, as transmitters. Other than pressure transmitters, which in normal operation are subjected to process pressure. In case of a test performed with liquid, the measuring chamber must be filled as far as possible without air bubbles. Adjust the zero, the trans-

mitter at atmospheric pressure and there, after slowly increase the static pressure in both measuring chambers. Read the value of the output after waiting for a time of minimum 10 seconds at the values of 0, 20, 40, 60, 80 and 100 percent of the rated static pressure. Calculate arithmetic mean of the output/signal output for each measuring points. The arithmetic mean of the highest and lowest expressed in percent of the output range in the complementary error of pressure difference transmitter due to static pressure change. This must be related to either to the total range or to the 10 percent value thereof.

7.2.17 Temperature of Process Fluid

If the process fluid is in contact with the measuring element in normal use and the temperature of the process fluid may influence the transmitter performance, then this test shall be carried out. It shall be performed by measuring the steady-state changes in lower range-value and span which result from changes in fluid temperature in four equal steps. The details of the test shall be agreed with the manufacturer. While the temperature is changing, the transmitter shall be energized, and an input signal shall be applied to maintain the output within the normal operating range. Changes in the output measured during the test shall be recorded.

7.2.18 Flow of Process Fluid Through the Instrument

This test shall be carried out on transmitters (other than flow-meters) which require for normal operation, that process fluid flows through some part of them.

It shall be carried out by measurement of the change in lower range-value and span caused by alteration of the flow rate through the transmitter from the minimum to the maximum specified by the manufacturer. The test fluid shall be subject to agreement between the user and the manufacturer.

7.2.19 Flow of Purge Gas Through the Transmitter

If purge gas, such as air or nitrogen, is applied to the case of a transmitter in a manner that creates a slight positive pressure within the case to ensure a gas flow from inside to outside of the transmitter, changes in lower range-value and span caused by an alteration of the flow rate of purge gas shall be measured with the flow adjusted to 0 percent, 50 percent and 100 percent of the maximum specified by the manufacturer.

Each measurement shall be taken 30 min after the purge gas flow has been set.

7.3 Stability

7.3.1 Start-up Drift

This test shall be carried out by measurement of the changes which occur in the output in the period immediately following application of the pneumatic or electrical power supply to the transmitter. Prior to the test, the transmitter shall be subjected to ambient environmental conditions or as advised by the manufacturer for a period of 24 h, but shall not have been energized.

With a 10 percent input signal applied to the transmitters, it shall be switched on and the output noted after 5 min, 1 h, and 4 h. The transmitters shall then be switched off, and after at least 24 h under ambient environmental conditions, the test shall be repeated with a 90 percent input signal. The measurements obtained shall be recorded to show the short-term drift characteristic of the transmitter.

7.3.2 Long-Term Drift

The transmitter shall be operated for 30 days with a steady input signal corresponding to 90 percent of span. The input and output shall be measured each day and the output drift determined, corrected by calculation for any small variation of input. Care should be taken that changes due to ambient environmental conditions, other than time, do not mask the effects of long-term drift. The lower range-value and span shall be measured and recorded immediately before and after the 30 days test period.

The transmitter should be kept in environmental chamber at controlled temperature and relative humidity. Stabilized supply should be used for the test. These parameters should also be continuously recorded during the test period.

7.3.3 Accelerated Operational Life Test

Transmitters incorporating mechanical or electro-mechanical parts shall be connected as for normal operation. An initial alternating input with peak-to-peak amplitude equal to half the span and centred at the mean of the upper and lower range-values shall be applied. The frequency shall be such that gain is not reduced below 0.8 unless otherwise agreed with the manufacturer, the transmitter shall be subjected to 100 000 measurement cycles. Lower range value, span and hysteresis at mid-span shall be measured before and after the test and any changes shall be recorded.

7.4 Other Tests

7.4.1 Ripple Content of Electrical Output

The peak-to-peak values and the principal frequency component of any ripple content of the output shall be measured and recorded with 10 percent, 50 percent and 90 percent input signals at minimum and maximum lead.

7.4.2 Insulation Resistance

This test shall be carried out by agreement with the manufacturer in accordance with local requirements.

7.4.3 Dielectric Strength Measurement

This test shall be carried out by agreement with the manufacturer in accordance with local requirements.

7.4.4 Power Consumption

7.4.4.1 Electrical power consumption

With the input adjusted so that power consumption is at its maximum value, the watts and volt-amperes consumed shall be measured and recorded. The measurement shall be made at the nominal specified by the manufacturer for the supply.

7.4.4.2 Pneumatic power consumption

The maximum air consumption of the transmitter shall be measured and recorded.

7.5 Effect of Open-Circuited and Short-Circuited Input

Each electrical input connection shall be interrupted in turn for 5 min and the ultimate steady-state outputs recorded. The times taken to reach these values shall also be recorded. A similar test shall be performed with the electrical input connection shorted together.

7.6 Effect of Open-Circuited and Short-Circuited Output

Each electrical output connection shall be interrupted in turn for 5 min and the steady-state voltage across the output terminals shall be recorded. The times taken to reach these values shall also be recorded. A similar test shall be performed with the electrical output connections shorted together. After the short-circuit test, the calibration of the transmitter shall be checked to determine whether any permanent change in calibration or damage has occurred.

8 DYNAMIC BEHAVIOUR

8.0 General

Testing shall be carried out with the span adjusted to the approximate mean of the maximum and minimum span and with the lower range-value set approximately at the mid-point of its permissible range of adjustment.

If there are other adjustments which modify the dynamic behaviour of the transmitter, tests shall be carried out with the adjustments set to have their minimum and maximum effects.

The load impedance value specified by the manufacturer shall be used. If no-value is specified, a 0.1 μF capacitor in parallel with the reference load resistance shall be used for transmitters with electrical output. For pneumatic transmitters, a test load consisting of an 8 m length of 4 mm internal diameter rigid pipe followed by a 20 cm^3 capacity shall be used.

8.1 Step Response

A series of step changes shall be applied to the input of the transmitters as specified below. The rise time of the step input shall be small compared with the transmitter response time, both being recorded for the following:

- a) Step corresponding to 80 percent of output span from 10 percent to 90 percent, then from 90 percent to 10 percent; and
- b) Steps corresponding to 10 percent of output span up and down as follows :
5 percent to 15 percent; 45 percent to 55 percent and 85 percent to 95 percent.

The time for the output to reach and remain within 1 percent of the span of its steady value shall be measured for each test condition.

The amount of dead time and overshoot, if any, shall be stated.

NOTE — If response is exponential, the times which correspond to 63 percent and 95 percent of the input step may also be useful.

8.2 Frequency Response

The peak-to-peak amplitude of the sinusoidal signal applied to the input shall be sufficient to allow a valid

measurement while keeping a relatively low value (not exceeding 20 percent of span). The frequency of the input signal shall be increased in increments from an initial value sufficiently low to approximate zero frequency conditions (not above 0.005 Hz) to a higher frequency at which the output is attenuated to approximately one-half of its initial amplitude.

At least one complete cycle of the input and output shall be recorded at each frequency step.

The results of these tests shall be presented graphically (see Fig. 7) in the following form:

- a) the gain relative to zero frequency gain shall be plotted against frequency on a logarithmic scale; and

- b) the phase lag between the output and input shall be plotted against frequency on a logarithmic scale.

From the graphs, the following shall be determined:

- i) the frequency at which the relative gain is 0.7;
- ii) the frequency at which the phase lag is 45° ; and
- iii) the maximum relative gain and the corresponding frequency and phase angle.

9 SUMMARY OF TESTS

9.1 The following tests as given in Table 3 are suitable for industrial process transmitters. In general each applicable test should be conducted on a given transmitter if a full evaluation report is planned.

Table 3 Test Schedule and Information

Designation	Information to be Reported		Reference to Clause or Sub-Clause
	Units	Remarks	
(1)	(2)	(3)	(4)
i) All transmitters			
a) Measured error	Percent of output span	Three to five upscale and downscale full range traverses, full range traverses, measuring at least five points. Compute errors and plot error curves	7.1.2
b) Conformity	Percent of output span	—	7.1.3
c) Hysteresis	Percent of output span	—	7.1.4
d) Repeatability	Percent of output span	—	7.1.5
e) Effect of dead band	Percent of output span	Vary input to obtain detectable output change at 0.5 percent, 100 percent output	7.1.6
f) Ambient temperature	Percent of output span	Two cycles at $+20^\circ\text{C}$, $+40^\circ\text{C}$, $+55^\circ\text{C}$, $+20^\circ\text{C}$, 0°C , -10°C , -25°C , $+20^\circ\text{C}$	7.2.10
g) Humidity	Percent of output span	Saturation induced	7.2.11
h) Mounting position	Percent of output span	$\pm 10^\circ$ inclination in two planes	7.2.12
j) Shock	Percent of output span after procedure	'Drop and topple' procedure in accordance with IS 9000 (Part 7/Sec 3) : 1979	7.2.13
k) Vibration	Percent of output span	Initial resonance search, 1.5 h endurance conditioning and final resonance search	7.2.14
m) Over-range	Percent of output span	Over-range for 1 min. Measure 5 min after return to lower range-value. Carried out in both directions if a differential pressure transmitter	7.2.15
ii) Drift			
a) Start-up	Percent of output span	At 5 min, 1 h, and 4 h after power is switched on	7.3.1
b) Long-term	Percent of output span	30 days at 90 percent of span	7.3.2
c) Accelerated life	Percent of output span	100 000 cycles of amplitude equal to half the span. Measure lower range-value, span, and hysteresis	7.3.3

Table 3 (concluded)

Designation (1)	Information to be Reported		Reference to Clause or Sub-Clause (4)
	Units (2)	Remark (3)	
iii) <i>Electric transmitters</i>			
a) Power supply	Percent of output span	Nine sets of measurements for variations in ac voltage and frequency; three sets for dc	7.2.1.1
i) Mains variations			
ii) Short interruption	Peak positive and negative percent of output span; time to stabilize	Nine repeated interruptions at crossover point of 1, 5, 10, 25 cycles	7.2.1.2
iii) Depression	Percent of output span; duration of output transient	At 75 percent of nominal supply voltage for 5 s	7.2.1.3
iv) Transient over voltages	Record any output transients	Two pulses of 100 percent, 200 percent and 500 percent of mains rms voltage	7.2.1.4
b) Electrical interference	Percent of output span	For transmitters with terminals isolated from earth 250 V rms, ac superimposed on isolated terminals at mains frequency then positive and negative 50 V superimposed on isolated terminals	7.2.4.1
i) Common mode			
ii) Series mode	Percent of output span	1 V or less, at mains frequency and 10 percent and 90 percent of output span	7.2.4.2
c) Earthing	Record transients	Only for transmitters with isolated terminals	7.2.5
d) Output load	Percent of output span	Vary load resistance from minimum to maximum as specified by manufacturers	7.2.6.1
e) Source impedance	Percent of output span	Vary input circuit resistance from minimum to maximum values specified by manufacturer	7.2.7
f) Radio interference		As specified by manufacturer	7.2.8
g) Magnetic-field Interference	Percent of output span	400 A/m at 10 percent and 90 percent of output span	7.2.9
h) Ripple	—	Peak-to-peak values and principle frequency components	7.4.1
j) Power consumption	Maximum watts and volt-amperes	At maximum supply voltage and minimum frequency specified by the manufacturer	7.4.4.1
k) Open and short circuits input	Time to stabilize	Interrupt each input connection and then short together	7.5
m) Open and short circuits-output	Time to stabilize	Interrupt each output connection and then short together	7.6
iv) <i>Pneumatic transmitters</i>	Percent of output span	Nominal reference supply pressure varied 10 percent with output at 100 percent of span	7.2.2
a) Supply variations			
b) Output load	See Fig. 6	Air bled from/into transmitter with input set at 10 percent, 50 percent and 90 percent of span	7.2.6.2
c) Power consumption	m ³ /h	Recorded for minimum and maximum input and maximum air consumption	7.4.4.2
v) <i>Dynamic behaviour</i>			
a) Step response	Record time for response to within 1 percent of output span of final value	Input steps corresponding to 80 percent and 10 percent of output span	8.1
b) Frequency response	See Fig. 7	Apply peak-to-peak amplitude of 20 percent of input span at frequencies necessary to vary dynamic gain from 1 to 0.7	8.2

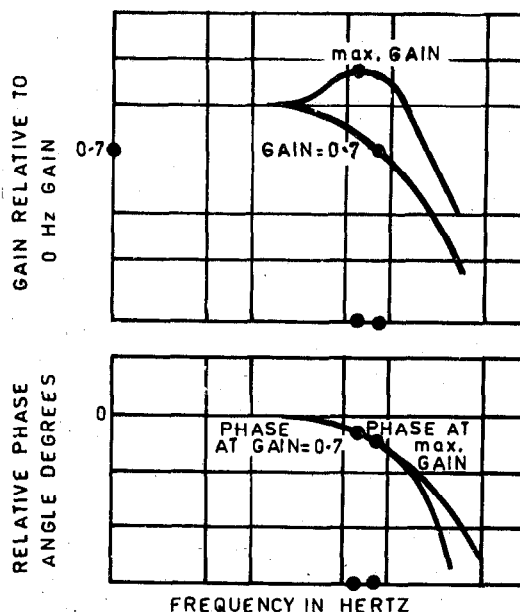


FIG. 7 FREQUENCY RESPONSE TEST RESULTS

ANNEX A

(Clause 2.1)

LIST OF REFERRED INDIAN STANDARDS

IS No.	Title	IS No.	Title
7722 : 1975	Analogue pneumatic signals for process control systems	(Part 4) : 1979	Damp heat (steady state)
7728 : 1984	Analogue dc current signals for process control systems (<i>first revision</i>)	(Part 5/Sec 1 and 2) : 1981	Damp heat (cyclic) test Section 1 16 + 8 h cycle, Section 2 12 + 12 h cycle
8493 : 1977	Analogue dc voltage signals for industrial process measurements and control systems	(Part 7/Sec 3) : 1979	Impact test, Section 3 Drop and topple
9000	Basic environmental testing procedures for electronic and electrical items	Part 8) : 1981	Vibration (sinusoidal) test
(Part 2/Sec 1 to 4) : 1977	Cold test, Section 1 General, Section 2 Cold test for non heat dissipating items with sudden change of temperature, Section 3 Cold test for non-heat dissipating item with gradual change of temperature, Section 4 Cold test for heat dissipating items with gradual change of temperature	Part 14/Sec 1 to 3) : 1988	Test N : Change of temperature, Section 1 Test Na : Rapid change of temperature (thermal shock) with prescribed time of transition-two chamber method (<i>first revision</i>), Section 2 Test Nb: Change of temperature (temperature cycling) with specified rate of change-one chamber method, Section 3 Test Nc: Rapid change of temperature (thermal shock) - Two fluid bath method (<i>first revision</i>)
(Part 3/Sec 1 to 3) : 1988	Dry heat test, Section 1 General, Section 2 and Section 3 Dry heat test for non-heat dissipating items with sudden change of temperature		

Standard Mark

The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act, 1986* and the Rules and Regulations made thereunder. The Standard Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well defined system of inspection, testing and quality control which is devised and supervised by BIS and operated by the producer. Standard marked products are also continuously checked by BIS for conformity to that standard as a further safeguard. Details of conditions under which a licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.